

# Chemistry

## Lecture 1

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### Fundamental Principles of Organic Chemistry

#### Outline:

- ✚ Classification of Organic compounds
- ✚ Isomerism

#### Organic Compounds

- Compounds of carbon, hydrogen and their derivatives.
- First synthesized in laboratory by Frederick Wohler.
- Rejected vital force theory.
- Prepared Urea from ammonium cyanate.
- Inorganic compounds containing carbon; CO, CO<sub>2</sub>, CS<sub>2</sub>, carbonates, bicarbonates, graphite, diamond, HCN etc.
- Major sources are coal, petroleum and natural gas.

#### Features of Organic compounds:

- ◆ Large no. of organic compounds due to self linkage property of carbon (Catenation).
- ◆ Non ionic in nature (Covalent bonding)
- ◆ Exist in form of homologous series [A series of organic compounds with same functional group/method of preparation but two successive members of the series differ by a CH<sub>2</sub> unit (by 14 amu by molar mass) i.e. alcohols etc]
- ◆ Complex large molecules
- ◆ Show isomerism
- ◆ Slow rate of reactions
- ◆ Mostly insoluble in water but soluble in non polar solvents
- ◆ Poor conductors in solution and molten form
- ◆ Flammable
- ◆ Low M.P/B.P and volatile
- So are classified on the basis of:

i) Structure

ii) Functional group

## Classification on basis of structure (arrangement of carbon atoms):

**Open chain/Acyclic/Aliphatic:** They are open chain compounds.

**Types:**

Straight chain	Branched chain
Carbon atoms are arranged in series.	At least one carbon atom is attached with main chain
<b>Example:</b> $\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_3$	<b>Example:</b> $\text{CH}_3\text{-CH}(\text{CH}_3)\text{-CH}_3$
Symmetrical	Asymmetrical
High B.P	Low B.P

**n-pentane > iso-pentane > neo-pentane**

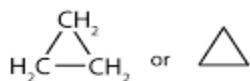
**Closed chain/Cyclic/Ring:** They have ring of atoms.

**Types:**

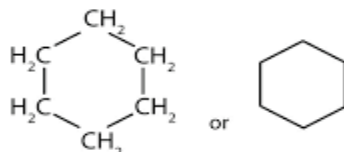
a) **Homocyclic/Carbocyclic:** Ring consisting of only carbon atoms (same atoms).

1. **Alicyclic:** have ring of three or more carbon atoms, having no benzene ring and resemble aliphatic compounds. Saturated alicyclic compounds have general formula  $\text{C}_n\text{H}_{2n}$ .

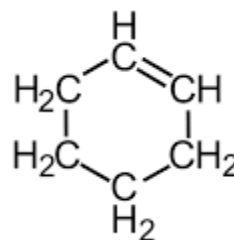
**Examples:**



cyclopropane



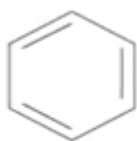
cyclohexane



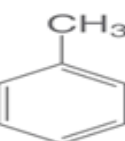
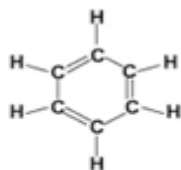
2. **Aromatic:** At least one benzene ring with alternative three double and three single bonds.

Aromatic compounds may have a side chain or functional group attached to ring. They may also have more than benzene rings fused together or isolated.

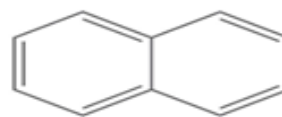
**Examples:**



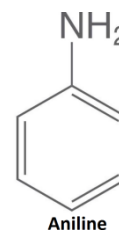
Benzene



Toulene



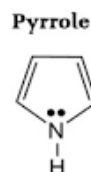
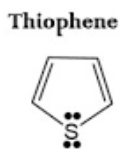
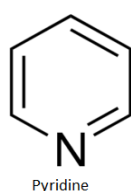
Naphthalene



Aniline

- b) **Heterocyclic:** Ring consists of more than one kind of atoms. The atoms other than carbon are called hetero atoms i.e. N, O, S.

**Examples:**



### Isomerism

**Def:** Same Molecular formula (M.F) but different (i) structural formula (S.F) (ii) spatial arrangement (iii) properties.

**Types:**

- a) **Structural isomerism:** Due to different arrangement of atoms/different structure.

Chain isomerism	Position isomersim	Functional group isomersim	Metamersim	Tautomersim
Same M.F but different length of carbon chain.	Same M.F but different position of the same functional group.	Same M.F but different functional group.	Same M.F but different no. of carbon atoms on either side of the functional group.	Isomerism arises due to shifting of proton within same molecule. Both tautomeric forms are different compounds and can be separated.
<b>Example:</b> n-pentane, iso-pentane and neo-pentane are the isomers of each other.	<b>Example:</b> $\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-Cl}$ and $\text{CH}_3\text{-CH}(\text{Cl})\text{-CH}_3$ are the isomers of each other.	<b>Example:</b> $\text{C}_2\text{H}_5\text{OH}$ and $\text{CH}_3\text{-O-CH}_3$ are isomers of each other.	<b>Example:</b> Diethyl ether and propyl methyl ether are isomers of each other.	<b>Example:</b> $\begin{array}{c} \text{H} \\   \\ \text{H}_2\text{N}-\text{C}-\text{COOH} \\   \\ \text{R} \end{array} \rightleftharpoons \begin{array}{c} \text{H} \\   \\ {}^+\text{H}_3\text{N}-\text{C}-\text{COO}^- \\   \\ \text{R} \end{array}$
All families (acyclic) can show the chain isomerism.	Ketones, alcohols, alkyl halides, alkenes, alkynes, disubstituted benzene can show Position isomerism.	Alcohols $\leftrightarrow$ Ethers Aldehyde $\leftrightarrow$ ketone C.A's $\leftrightarrow$ Esters can show Functional group isomerism.	Ethers, Esters, Secondary amines, ketones, sulphides (R-S-R) can show metamerism.	Keto-enol forms: $\text{CH}_3\text{CHO}$ and $\text{CH}_2=\text{CH-OH}$ are tautomers.

- b) **Stereoisomerism:** Isomerism is caused by the different arrangements/orientation of atoms or groups in space but molecular and structural formula same.

Optical Isomerism	Geometrical Isomerism
<p>Optical active compound can exist in two isomeric forms which rotate plane polarized light in opposite directions. These are called optical isomers and phenomenon is called optical isomerism.</p> <p><b>Condition:</b>            Presence of <b>chiral centre</b> (<math>sp^3</math> carbon to whom all four groups attached are different is a chiral centre)</p> <ul style="list-style-type: none"> <li>The isomer that rotates plane polarized light to right (clockwise) is called <b>Dextrorotatory isomer (+)</b></li> <li>The isomer that rotates plane polarized light to the left (anti-clockwise) is known as <b>Levorotatory isomer (-)</b></li> </ul> <p>These both are enantiomers of each other</p>	<p>Same M.F and S.F but different position of identical groups in space.</p> <p><b>Conditions:</b></p> <ul style="list-style-type: none"> <li>❖ Presence of double bond.</li> <li>❖ No free bond rotation.</li> <li>❖ Different groups attached to both double bonded carbons.</li> </ul> <p>Therefore 2-butene shows while 1-butene doesn't.</p> <p><b>Types:</b>            Cis and Trans which are diastereomers of each other</p>

Cis-form	Trans-form
Identical groups on same side of double bond <ul style="list-style-type: none"> <li>• Unsymmetrical</li> <li>• Low M.P</li> <li>• Dipole moment <math>\neq 0</math></li> <li>• Polar</li> <li>• High B.P</li> </ul>	Identical groups on opposite side of double bond <ul style="list-style-type: none"> <li>• Symmetrical</li> <li>• High M.P</li> <li>• Dipole moment = 0</li> <li>• Non polar</li> <li>• Low B.P</li> </ul>

### Functional Group

**Def:** Atom, group of atoms, double bond or triple bond whose presence imparts specific properties to organic compound.

- ◆ It is the basis of nomenclature to classify organic compounds.
- ◆ Gives information about chemical reactions.

Following are some examples given:

Functional group		Class of compounds	Example
Formula	Name		
	None	Alkane	$\text{CH} - \text{CH}_3$
	Double bond	Alkene	$\text{H}_2\text{C} = \text{CH}_2$
$-\text{C}\equiv\text{C}-$	Triple bond	Alkyne	$\text{HC}=\text{CH}$
$-\text{X}(\text{X}=\text{F}, \text{Cl}, \text{Br}, \text{I})$	Halo (fluoro, chloro, bromo, iodo)	Alkyl halide	$\text{CH}_3-\text{CH}_2-\text{Cl}$
$-\text{OH}$	Hydroxyl group	Alcohol or alkanol	$\text{CH}_3-\text{CH}_2-\text{OH}$
$-\text{NH}_2$	Amino group	Amine	$\text{CH}_3-\text{CH}_2-\text{NH}_2$
	Imino group	Imine	$\text{CH}_2=\text{NH}$
	Ether linkage	Ether	$\text{CH}_3-\text{CH}_2-\text{O}-\text{CH}_2-\text{CH}_3$
	Formyl group	Aldehyde or alkanal	
	Carbonyl	Ketone or alkanone	
	Carboxyl group	Carboxylic acid (or alkananoic acid)	
$-\text{C}(=\text{O})-\text{X}$	Acid halide	Acid halide	
$-\text{C}(=\text{O})\text{NH}_2$	Acid amide	Acid amide	
	Ester group	Ester	
$-\text{SH}$	Mercapto	Thioalcohol or Thiol	$\text{CH}_3-\text{CH}_2-\text{SH}$
$-\text{C}\equiv\text{N}$	Cyano	Alkyl cyanide or alkanenitrile	$\text{CH}_3-\text{C}\equiv\text{N}$
	Nitro	Nitro compounds	$\text{C}_6\text{H}_5\text{NO}_2$

A molecule containing more than one functional groups in its structure is called **poly-functional molecule**. In such case priority order is followed;

- ☛ Priority order followed when more than one functional groups are present:



- ✓ If more than one functional groups are present, parent name will be with the functional group coming first in priority order and other one will be treated as substituent.

### Alkyl/Aryl Radicals:

1. Methyl ( $\text{CH}_3-$ )

2. Ethyl ( $\text{C}_2\text{H}_5-$  or  $\text{CH}_3\text{-CH}_2-$ )

3. (i) n-propyl ( $\text{C}_3\text{H}_7-$  or  $\text{CH}_3\text{-CH}_2\text{-CH}_2-$ )

(ii) iso-propyl ( $\text{CH}_3\text{-CH-CH}_3$ )

4. (i) n-butyl ( $\text{C}_4\text{H}_9-$  or  $\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_2-$ )

(ii) iso-butyl or secondary butyl ( $\text{CH}_3\text{-CH-CH}_2\text{-CH}_3$ )

(iii) Tertiary butyl ( $\text{CH}_3\text{-C-CH}_3$ )  
 $\text{CH}_3$

5. Phenyl ( $\text{C}_6\text{H}_5-$ )

6. Benzoyl ( $\text{C}_6\text{H}_5\text{CO-}$ )

7. Benzyl ( $\text{C}_6\text{H}_5\text{-CH}_2-$ )

8. Benzal ( $\text{C}_6\text{H}_5\text{-CH-}$ )

9. Benzo ( $\text{C}_6\text{H}_5\text{-C-}$ )

10. Vinyl ( $\text{CH}_2=\text{CH-}$ )

### Important Concepts:

- ☛ Carbon directly attached to functional group is called **alpha carbon**, carbons directly attached to alpha carbon are called **beta carbons** and carbons directly attached to beta carbon are called **gamma carbons**.
- ☛ In case of alkanes, a carbon which is directly attached with one carbon is termed as **primary carbon**, a carbon which is directly attached with two carbons is termed as **secondary carbon**, a carbon which is directly attached with three carbons is termed as **tertiary carbon** and a carbon which is directly attached with four carbons is termed as **quaternary carbon**.
- ☛ A carbon bearing (i) free radical dot, (ii) positive charge, (iii) negative charge, (iv) a bond i.e — or directly attached to a functional group;
  - ☞ If such carbon is further directly attached to one carbon, it is called **primary carbon**.
  - ☞ If such carbon is further directly attached to two carbons, it is called **secondary carbon**.
  - ☞ If such carbon is further directly attached to three carbons, it is called **tertiary carbon**.